

Quality of Knowledge in Virtual Entities

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INTRODUCTION

The work done by some authors in the fields of computer science, artificial intelligence, and multi-agent systems foresees an approximation of these disciplines and those of the social sciences, namely, in the areas of anthropology, sociology, and psychology. Much of this work has been done in terms of the humanization of the behavior of virtual entities by expressing human-like feelings and emotions.

Some authors (e.g., Ortony, Clore & Collins, 1988; Picard, 1997) suggest lines of action considering ways to assign emotions to machines. Attitudes like cooperation, competition, socialization, and trust are explored in many different areas (Arthur, 1994; Challet & Zhang, 1998; Novais et al., 2004). Other authors (e.g., Bazzan et al., 2000; Castelfranchi, Rosis & Falcone, 1997) recognize the importance of modeling virtual entity mental states in an anthropopathic way.

Indeed, an important motivation to the development of this project comes from the author's work with artificial intelligence in the area of knowledge representation and reasoning, in terms of an extension to the language of logic programming, that is, the Extended Logic Programming (Alferes, Pereira & Przymusinski, 1998; Neves, 1984). On the other hand, the use of null values to deal with imperfect knowledge (Gelfond, 1994; Traylor & Gelfond, 1993) and the enforcement of exceptions to characterize the behavior of intelligent systems (Analide, 2004) is another justification for the adoption of these formalisms in this knowledge arena.

Knowledge representation, as a way to describe the real world based on mechanical, logical, or other means, will always be a function of the systems ability to describe the existent knowledge and their associated reasoning mechanisms. Indeed, in the conception of a knowledge representation system, it must be taken into attention different instances of knowledge:

- **The Existent Knowledge:** It will not be known in all its extension because it characterizes all the circumstances of the universe of discourse, known or unknown.
- **The Observed Knowledge:** Acquired by the experience, it must be noticed that it may depend upon the observer education, state of mind, and prejudices (to state a few).
- **The Represented Knowledge:** With respect to a certain objective, it may be irrelevant to represent a given set of data. This is the information that must be represented and understood.

In a classical logical theory, the proof of a question is made in terms of being true or false, or in terms of representing something about which one could not be conclusive. In spite of that, in a logic program, the answer to a question is only of two types: it can be true or false. This is due to the fact that a logic program shows some limitations in terms of knowledge representation. (It is not allowed explicit representation of negative information.) In addition, in terms of an operational semantics, it is applied the Closed World Assumption (CWA) to all the predicates.

The generality of the programs written in logic represents implicitly negative information, assuming the application of reasoning according to the CWA. An extension of a logic program may comprise negative information (Alferes et al., 1998; Neves, 1984), as well as directly describe the CWA for some predicates. Consequently, it is possible to distinguish three types of conclusions for a question: *true*, *false* or, when there is no information inferring one or another, the answer will be *unknown*.

In this work, the subject related with the qualitative knowledge is discussed behind the assumption that, when a system needs to reason about the real world, it must have the ability to infer upon imperfect knowledge. Hence, this knowledge imperfection may have an important role in the quality of the whole system when considered as a part of a wider community of virtual entities with a rich knowledge component, having sophisticated properties such as planning, reactivity, learning, cooperation, communication, and argumentation. Agent societies may mirror a great variety of human societies with emphasis on behavioral patterns and predefined roles of engagement and obligation.

PRELIMINARIES

Knowledge and belief are generally incomplete, contradictory, or error sensitive, being desirable to use formal tools to deal with the problems that arise from the use of incomplete, contradictory, ambiguous, imperfect, nebulous, or missing information. This work is supported by the developments in Analide (2004) where the representation of incomplete information and the reasoning based on partial assumptions is studied, using the representation of null values (Analide & Neves, 2000; Neves, 1984) to characterize abnormal or exceptional situations. The ELP language presents itself as a formal and flexible tool to obtain a solution for the problems just referred.

Null Values

The identification of null values emerges as a strategy for the enumeration of cases, for which one intends to distinguish between situations where the answers are *known* (true or false) or *unknown* (Analide & Neves, 2000; Traylor & Gelfond, 1993).

The representation of null values will be scoped by the ELP. In this work, two types of null values will be considered: the first will allow the representation of unknown values, not necessarily from a given set of values, and the second will represent unknown values from a given set of possible values.

Consider the following as a case study to show some examples of how null values can be used to represent unknown situations. Consider the implementation of a time table to express the departure of trains through the predicate:

connect: City \times Time

where the first argument denotes the city of departure and the second represents the time of arrival (e.g., connect(guimarães,17:00) denotes that the Guimarães's coming train is expect to arrive at 17 o'clock, Program 1).

Program 1. Extension of the predicate that describes arrivals at the train station:

```
connect( guimarães,17:00 )
¬connect( C,T ) ←
    not connect( C,T )
```

In Program 1, the symbol \neg denotes the strong negation, denoting what should be interpreted as *false*, and the term *not* designates negation by failure.

Unknown

Following the example given by Program 1, one can admit that the connection from Oporto has not yet arrived. This situation will be represented by a null value of the type *unknown* that should allow the conclusion that the connection exists but to which it is not possible to be affirmative with respect to the arrival time (Program 2).

Program 2. Information about Oporto connection with an unknown delay:

```
connect( guimarães,17:00 )
connect( oporto,⊥ )
¬connect( C,T ) ←
    not connect( C,T ) ∧ not exception( connect( C,T ) )
```

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